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# Wildlife population monitoring: some practical considerations

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*Abstract*. The accurate estimation of wildlife population density is difficult and requires considerable investment of resources and time. Population indices are easier to obtain but are influenced by many unknowns and the relationships to actual population densities are usually unclear. Wildlife biologists, whether in the public or private sector, often find themselves in difficult situations where a resource manager or landowner wants good information, quickly, at low cost, and without clear objectives. In many situations, in addition to establishing clear objectives, a budget and timeframe, a biologist must understand and deal with the reality of many logistical concerns that will make the achievement of the objectives difficult or impossible. The situation is often complicated because the biology and ecology of the species of interest may be poorly understood in the specific setting and the species may be very rare or strongly influenced by current or past human activities. Methods to monitor a wildlife population may need to be tested or validated, extending the time and resources needed to complete the assigned task. In this paper, I discuss many of the challenges faced and the decisions to be made when a biologist is requested to provide useful, timely information on the status of a wildlife population.

## Introduction

There are many reasons why natural resource managers need to monitor wildlife populations. A large array of methods has been developed and used to that purpose (Seber 1982, 1986, 1992; Lancia *et al*. 1994; Thompson *et al*. 1998; Schwartz and Seber 1999). The biologist assigned the task, however, should be aware of the many factors and difficulties that can hinder the successful outcome of a monitoring effort. Because the determination of wildlife population abundance or density can be very difficult and expensive, one should have a clear set of objectives and adequate resources available for the task. Additionally, one must carefully select one or more field methods to apply to the population of interest. Many considerations can influence the method(s) selected and the value and accuracy of the data that result. Finally, implementing the monitoring strategy can be fraught with difficulties, especially when applied in remote or restricted areas or in lesser-developed countries. Careful planning and the anticipation of problems are required to improve the chances of success given the many things that can go wrong.

In this paper, I discuss the practical side of important factors (objectives, method selection and implementation) involved in monitoring wildlife populations. My intention is to aid future practitioners from revisiting many of the difficulties that have been encountered in the past. I do not discuss models, statistical formulations and assumptions, or the evaluation of datasets in the estimation of wildlife population abundance or density. These topics have been well covered in several books and reviews (e.g. Seber 1982, 1986, 1992; Lancia *et al*. 1994; Thompson *et al*. 1998; Schwartz and Seber 1999).

## Population monitoring objectives and situations

There are many diverse reasons why we need to monitor wildlife populations (Caughley 1977). For example, the population may be a valued game species (e.g. deer, bear, grouse) that is being managed on a sustained-yield basis. The population may be an actual or potential pest species (e.g. rodents, flocking birds, invasive/non-native species) capable of causing agricultural, property, or natural resource damage or of posing a human or livestock disease or safety hazard. We may need to assess the status of an endangered or threatened species or the progress of a recovery program for that species. We may need to determine the status of a purposeful introduction or reintroduction of a wildlife species to an area. We may be trying to define the biological diversity or 'ecological health' of an area and to monitor changes over time. We may desire to know the effects of our management actions or land-use practices or alternative activities on one or more 'featured or indicator' species.

The actual impetus for population monitoring may be curiosity, basic research, or interest in long-term population trends (e.g. breeding bird survey), but more often has a basis in agency mandates (e.g. federal, provincial, territorial, and state wildlife or conservation agencies), the regulatory arena (e.g. the *Endangered Species Act* and *National Environmental Policy Act* in the USA; the *Migratory Bird Treaty Act* in Canada, Mexico and USA; the *Conservation Act* in Canada and New Zealand; the *National Parks and*


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*Wildlife Conservation Act* in Australia), or in actual or potential judicial action (e.g. law suit, court injunction). Financial aspects (e.g. funding allocations, economic value or liability of the species, damage compensation) may also play a role in some situations.

Whether a biologist works in the private or public sector, the person will answer to a contractor, sponsor, or supervisor (henceforth, I will use the term contractor) when undertaking a wildlife population-monitoring assignment. Even if we assume that the biologist will have an appropriate and adequate amount of training and experience for the task at hand, he or she may be constrained in various ways that could hinder the success of the effort. Typically, the contractor will want a lot of information, at little expense, in a short period. Additionally, the contractor may not be able to provide much specific background information on the species or habitats in the setting of interest.

What is often most awkward for the biologist is that the objectives of the population monitoring are not clear or well defined. Although the contractor may request 'the absolute numbers, or highly accurate densities, of animals by habitat or land-use type over a large area', that is often not what the person really needs to make management decisions. Furthermore, the contractor most often does not have a realistic idea of what a request worded in that way would require in terms of time, personnel and resources. In some cases, the contractor will actually want multiple species monitored, not realising that each may require a very different monitoring method.

The biologist must address a number or questions with the contractor or determine answers on his/her own before designing and undertaking the monitoring project:

How will the data be used?

- What specific question(s) is (are) being asked: is the contractor actually needing density estimates, or monitoring long-term trends, or doing relative comparisons?
- Would a population index suffice or is a density estimate needed?
- What level of accuracy is needed for the purposes of management decisions?
- Will the results be used to assess the activities of others (e.g. game harvest rate, pest-control contract)?
- Are current on-the-ground activities affecting the population in a way that could influence efforts to monitor the population?
- Is monitoring required of one or multiple species?
- Is the population considered to be relatively stable or in a substantial increase or decline phase?
- Is there an adequate knowledge of the species' biology and ecology in the location of interest?
- Will this be a one-time effort or will a long-term monitoring program be established based on the project protocol and outcome?

Only when these questions are adequately answered can the biologist begin stipulating the appropriate method(s), personnel and resource needs, and a realistic timeframe for the project. Additionally, the biologist must have a good concept of how the proposed project might be affected by site variables, previous or on-going activities in the area, logistical problems, and a host of other factors – any or all of which might hinder a successful outcome. Adequate amounts of tedious, time-consuming, up-front work by the biologist can go a long way in reducing problems and frustrations as the work proceeds.

**Selection of monitoring method(s)**

Many species of mammals are difficult to monitor because of their small size, drab coloration, and secretive habits (Engeman and Witmer 2000). Additionally, many are nocturnal, some are fossorial, and many occur at low densities (e.g. rats: Quy *et al*. 1993; rabbits: Litvaitis and Litvaitis 1996; mustelids: Bull *et al*. 1992). Field work may be required in rugged, remote areas, and areas of dense vegetation (e.g. Tracey *et al*. 2005). Islands, mountainous areas, less developed countries, and military bases are good examples of locations that pose many challenges to the field biologist.

A large number of methods have been used to monitor terrestrial vertebrates (e.g. Caughley 1977; Davis 1982), although many methods have not been compared or validated with a more rigorous method of density estimation or a known population size (but see exceptions: Quy *et al*. 1993; Dodd and Murphy 1995). The methods include, for example, direct observation (day or night) of individuals, mark–recapture/resight, removal, and transects and variable plot surveys (see examples presented in Thompson *et al*. 1998). A large number of 'indirect' methods, often referred to as population or abundance indices (Thompson and Fleming 1994; Engeman and Allen 2000) or activity indices (Quy *et al*. 1993), have also been used. These methods do not rely on directly seeing or hearing the animals, but merely noting some form of 'sign' that tells us that the animals have been in the area: track stations, faecal counts, food removal, open or closed burrow-opening counts, burrow counts, runway counts, knockdown cards, snow tracks, or responses to audio calls (Engeman and Witmer 2000). These indices are based on the concept that a fixed amount of searching effort will locate a fixed proportion of the population. Furthermore, it is assumed that the index is proportional to the density and that the rate of proportionality is (relatively) constant (Caughley 1977). If the index doubles, we assume that the population has doubled. Some people might be more comfortable in calling this approach an 'activity index,' because we usually do not know the exact relationship of the index to the population density or how that relationship may change over time and space. For example, if three sets of tracks are found at a track station, we do not know if those were made by one, two, or three individual animals, but that there was three times as much 'activity' than at a track station, which had only one set of tracks (Allen *et al*. 1996). On the other hand, we typically find more sets of tracks (or, for example, more food removed from a bait station) where there is a larger population (Witmer, unpublished data on voles). Hence this approach provides a useful 'relative' index of the abundance of the animals using the area of interest. Technological developments have provided additional methods for monitoring populations such as the use of remote cameras (Bull *et al*. 1992; Glen and Dickman 2003), infrared thermal imaging (Boonstra *et al*. 1994), DNA analysis (Foran *et al*. 1997), and radio-isotope detection (Elbert *et al*. 1999).

Lancia *et al*. (1994) classified population-monitoring methods in three major categories with several sub-categories:

(1) Population estimate where all animals can be seen
   (a) Complete census/counts
   (b) Census from sample plots
(2) Population estimate where not all animals can be seen
   (a) Capture: (i) Mark–recapture/resight; (ii) Removal
   (b) Counts along transects or variable plots
(3) Population index

In selecting a method, the biologist must consider a number of factors in addition to resources and personnel availability. What is the likelihood of seeing or capturing the animal or its 'sign'? What portion of the entire area of interest can be sampled and how will samples be distributed? The answers to these questions will help the biologist select from the suite of methods described by Lancia *et al*. (1994). Of course, if there is a well-established and accepted method for monitoring the species in the setting of interest, the job may be easier for the biologist. If this is not the case, the biologist must select a method after careful consideration of a number of factors:

- The advantages and disadvantages of the method
- The assumptions of the method and the ability to meet them
- The method's practicality and 'user-friendliness'
- The general applicability or specialised nature of the method
- Situations and conditions under which the method can be used
- The repeatability of the results obtained
- The extent to which the method has been, or can be, tested or validated.

The biologist may choose to apply two methods, compare the results and decide which method will produce adequate results with the lowest commitment of personnel and resources. This 'double sampling' approach can be used to determine whether a population index (such as track counts or food removal) correlates well with a more rigorous method of population estimation (such as total capture or mark–recapture). Too often, population indices are used without this validation step (e.g. Thompson and Fleming 1994). Glen and Dickman (2003) recently compared two methods of estimating bait removal by target and non-target animals: sand track stations provided a less reliable method when compared with the results of remote photography. On the other hand, Edwards *et al*. (2000) compared two methods of estimating relative abundance of carnivores: passive track station surveys were more time-efficient and offered higher precision than spotlight surveys. These examples also illustrate the concept that different methods may be better or worse under different locations or circumstances.

In some cases, the contractor may require that two methods be used. For example, the United States Environmental Protection Agency requires the use of two population-monitoring methods in the determination of the efficacy of a rodenticide (Schneider 1982). Efficacy is based on the percentage reduction in the rodent population. In this case, the biologist might use the capture rate per 100 trap-nights, using snap traps in both reference and rodenticide-treatment areas. The second method could be mark–recapture sessions before and after the rodenticide application, using live traps.

It is especially important to make sure that the results obtained from the population monitoring method are not affected or biased by human activities. For example, spotlight counts at night can be used to monitor nocturnal mammals (Poole *et al*. 2003). If this same population has been suppressed by spotlight shooting, however, the method should not be used for population monitoring because the animals may have become light- and vehicle-shy (Bayne *et al*. 2000; Caley and Morley 2002).

## Implementation: overcoming logistics and other difficulties

After having selected an appropriate method, getting the contractor's approval, and marshalling adequate personnel and resources, the biologist may still face many challenges in producing a population estimate or an index to the number of animals using the area. Careful planning, including contingency plans, will help assure a successful outcome. The probability of success and the number of complications will generally be related to the attributes of the area in which the work is to be done.

### *Communication and transportation*

The biologist may be faced with cultural and language challenges. In some cases, it may be necessary to have an interpreter on site. Cultural considerations may require some changes in the planned work schedule. There may be relatively frequent turn-over in agency or military personnel, which makes consistent activity over time and space difficult. Vagaries in transportation to and from study sites may affect or prevent a consistent pattern of data collection. There may be 'black-out' areas where no radio-communication can occur between field crews and oversight personnel or 'black spots' where the radio-signal cannot be sent or received.

*Access*

In some cases, access to certain areas that the biologist needs to sample may be prevented or restricted; for example, the area may be considered dangerous, there may be military closures, or private landowners may forbid access. Military areas may, in some cases, be accessed with appropriate escort. In Australia and New Zealand, land-management agencies and indigenous landowners provide permits for research work on native animals and/or on their lands. A good public relations effort may allow access to some private lands. There may be training requirements before some areas can be accessed and, for many areas, a permit is often required. In any case, the existing road system is a large determinate of how much area can be efficiently accessed.

*Equipment and supplies*

A big challenge for the biologist is getting the equipment where it is needed in a timely fashion. If equipment has to be shipped, plenty of delivery time has to be allowed for. Also, putting all of an essential type of equipment in one shipment container may cause problems and it is better to spread the items out across containers should one container become lost or delayed in shipment. Additionally, the biologist can usually count on some equipment failures; equipment vandalism may also occur. Having back-up equipment or repair materials should be considered a wise investment. Personnel need to be trained in the proper use and repair of basic equipment. This will help ensure that the equipment is properly and consistently used. There are restrictions on the use of some kinds of equipment (e.g. traps, radio-telemetry frequencies) and permits are required for their use in some cases. Another type of permit is often required if animals are to be captured or handled. In addition to the basic field equipment, the field crew must have all the living supplies that they will need (e.g. water, food, fuel, cooking gear, clothing and bedding), which can be a sizable quantity for extended field studies. The ability to gather and deliver these materials will often dictate the maximum duration of the field work that is possible, and the physical and mental well-being of the field crew during, and at the end of, the field work.

*Personnel safety*

The biologist is responsible for the safety of personnel conducting fieldwork under his or her supervision and there are certain occupational health and safety requirements that need to be followed. Attention must be given to adequate briefing and training of personnel. In very remote areas, a well-provisioned first aid kit with supporting medications is essential in case of serious injury or illness. It is important that the biologist and field personnel are aware of any dangerous plants, animals, or disease hazards in the area. Contingency plans need to be in place in case of a serious accident or illness. Work in rugged, remote areas poses many safety challenges and the 'buddy' system is recommended. Reliable communication and transportation systems are needed in case an accident should occur. Emergency medical evacuation requires time and is usually very expensive. Night work poses its own set of risks and challenges. Personnel should not drive when overly tired even though population monitoring often requires long days and much driving. Periodic physical activity should be encouraged when long sessions of driving or observation are required. The supervisor should also ensure that periodic rest breaks are taken during long sessions of physical field activity.

*Other complications*

Land-use practices in the area to be sampled are usually not under the control of the biologist. These practices may include livestock grazing, burning, logging, chemical spraying or other activities that can affect the project outcome and, in some cases, the health and safety of project personnel. Careful coordination and frequent communication with resource managers and landowners in the area is essential to avoid conflicts. Severe weather events can also hinder a sampling effort and restrict access to areas. With some care, these events will rarely jeopardise the safety of the field personnel; however, they may more frequently damage or destroy plots, transects, and equipment. Finally, if there are rare or protected species of plants or animals in the area to be surveyed, care should be taken so that the procedures and equipment used do not adversely affect any of those species.

*Conclusions*

A biologist is often faced with the challenge of providing adequate information on the status of a wildlife population so that resource managers and landowners can make appropriate management decisions. The biologist must select appropriate monitoring methods and plan for the successful completion of the field project. It is important that the biologist has a clear, well defined objective and adequate personnel and resources. Detailed planning should start early, with the allowance of plenty of extra time before and during the scheduled field effort. Not only should adequate equipment be packed and shipped, but back-up equipment and repair materials need to be included. It is essential to consider that complications and problems can occur and to have contingency plans. Effective, frequent communication should be maintained with everyone involved in the project. Finally, having some highly motivated, trained and experienced personnel involved in the field work can go a long way towards the success of the population-monitoring project.

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